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36 Separate items are enclosed

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CT

✓ Spreadsheet
✓ DTS

MEMORANDUM FOR PRS (~~Contractor~~/In-House Publication)

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SUBJECT: Authorization for Release of Technical Information, Control Number: AFRL-PR-ED-TP-FY99-0134
C.T. Liu, "Influence of Near Tip Damage on the Initiation Fracture Toughness of a Particulate Composite"
1999 ASME Summer Conference Presentation **(Public Release)**

Influence of Near Tip Damage on the Initiation Fracture Toughness of a Particulate Composite

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Objectives

Investigate the Effects of Crack Tip damage, Specimen Thickness, and Initial Crack length on the Initiation Fracture Toughness of a Particulate Composite Material.

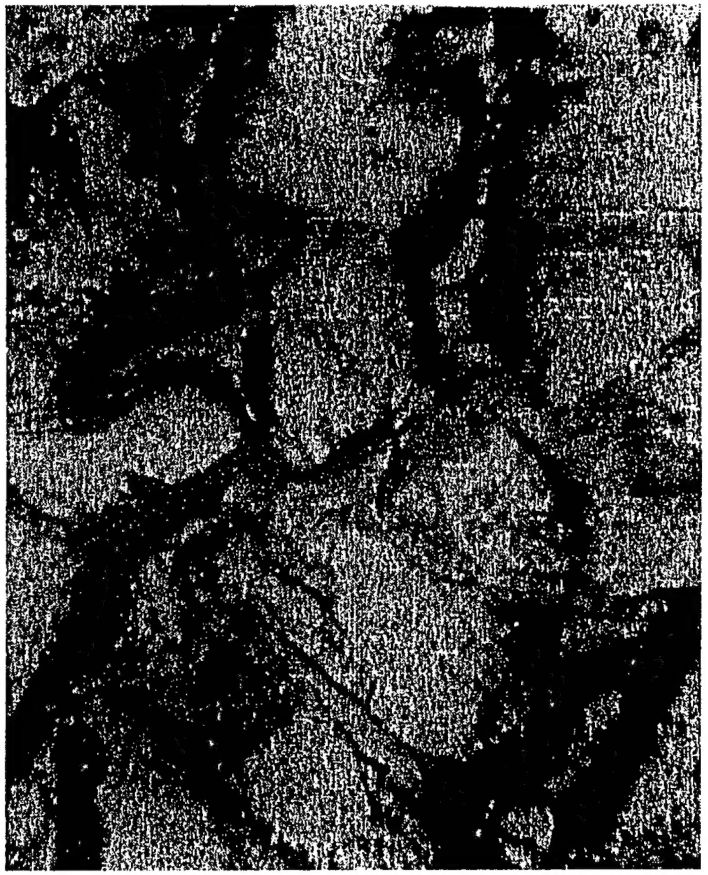
Specimen Thickness : 0.2 in, 0.5 in, 1.0 in, and 1.5 in.

Initial Crack Length : 0.1 in, 0.2 in, 0.3 in, and 0.4 in.

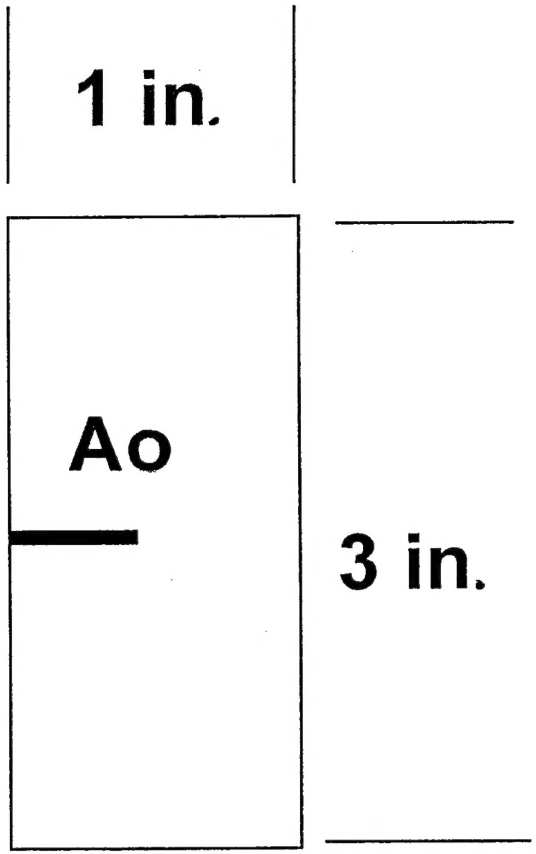
Local Dewetting About Filler Particles in Propellant

Direction of Strain

Unstrained



30% Strain



Specimen Geometry

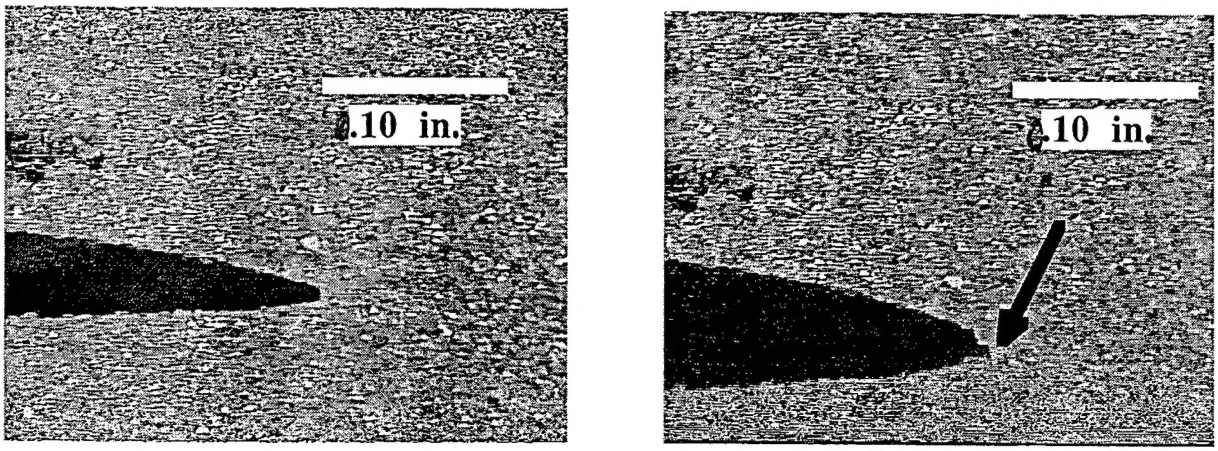


Figure xx - Crack initiation, 1.0'' thickness, .30'' initial crack length.

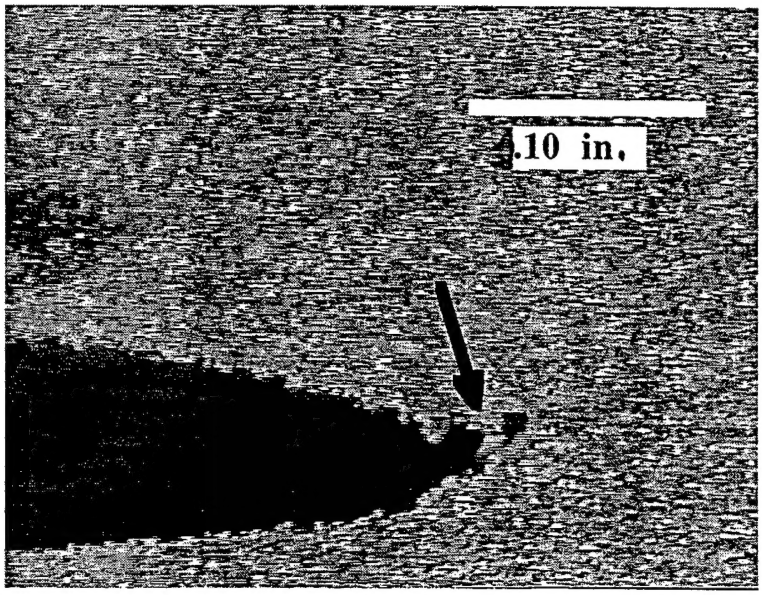


Figure xx - Ligament formation, 1.50" thickness.

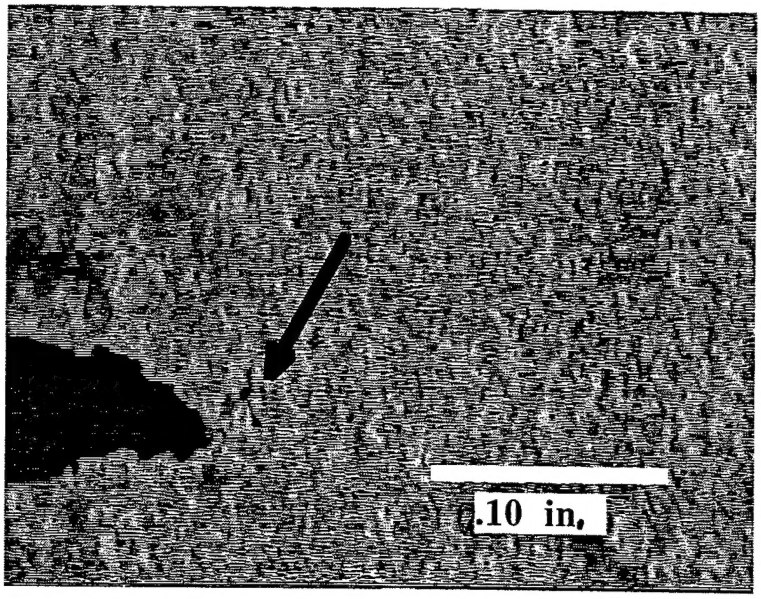


Figure xx - Damaged region ahead of crack tip, 1.5% thickness.

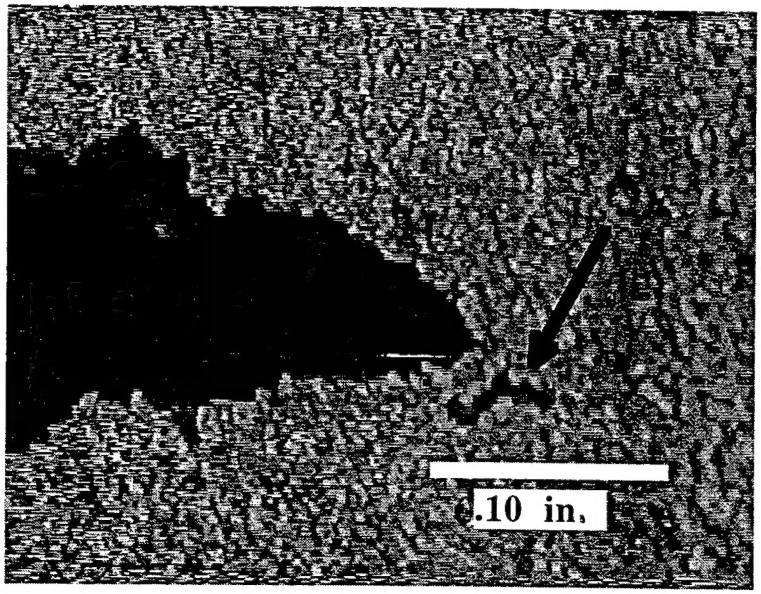


Figure xx - Damaged region ahead of crack tip, 2.7% thickness.

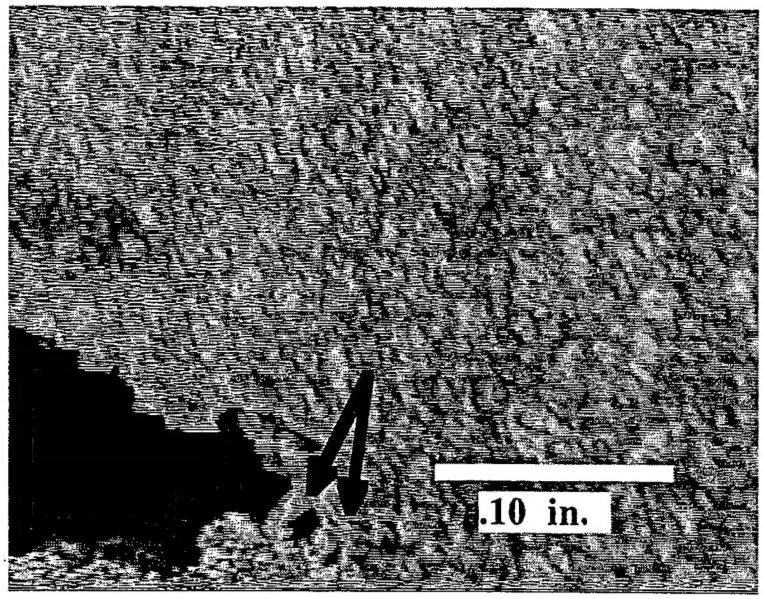


Figure xx - Double ligament formation ,050" thickness.

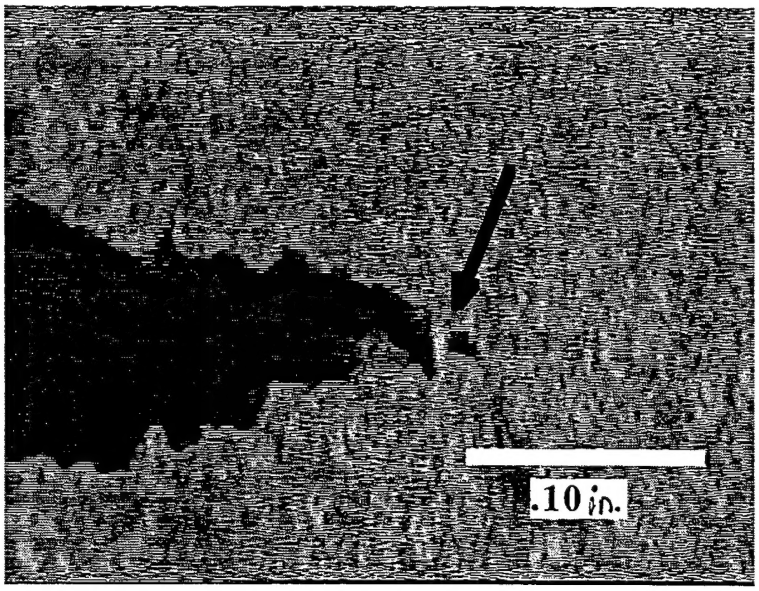
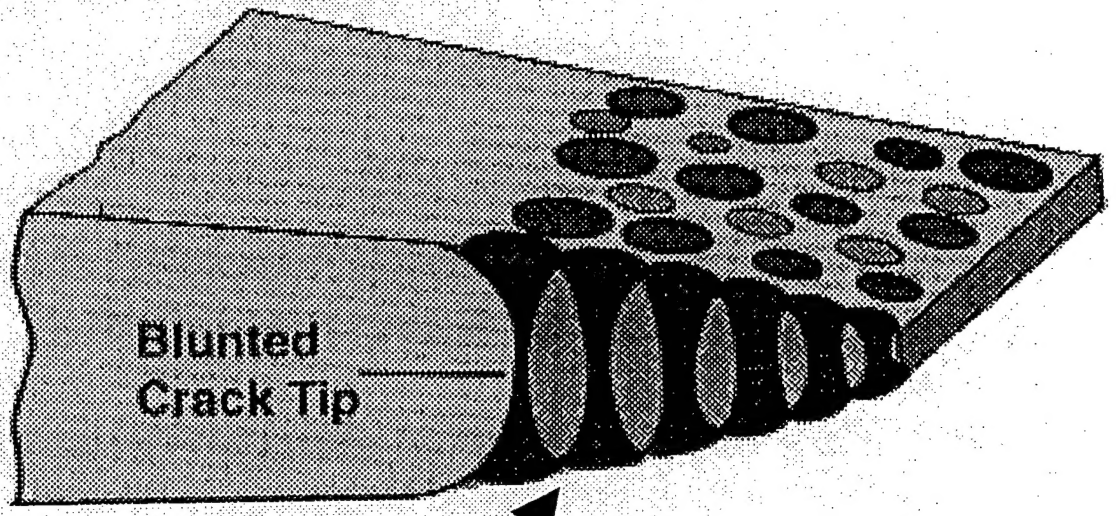
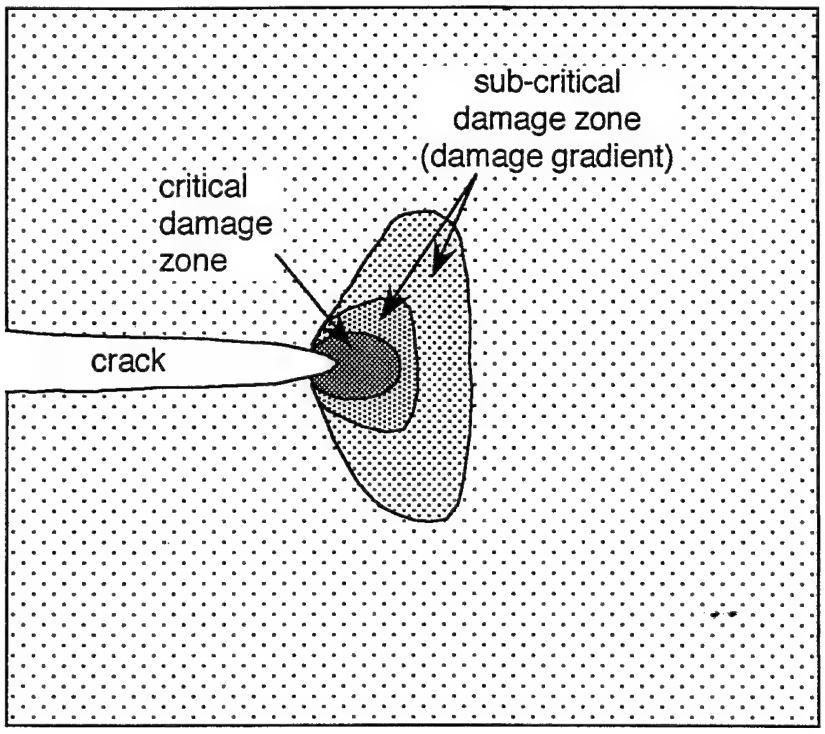


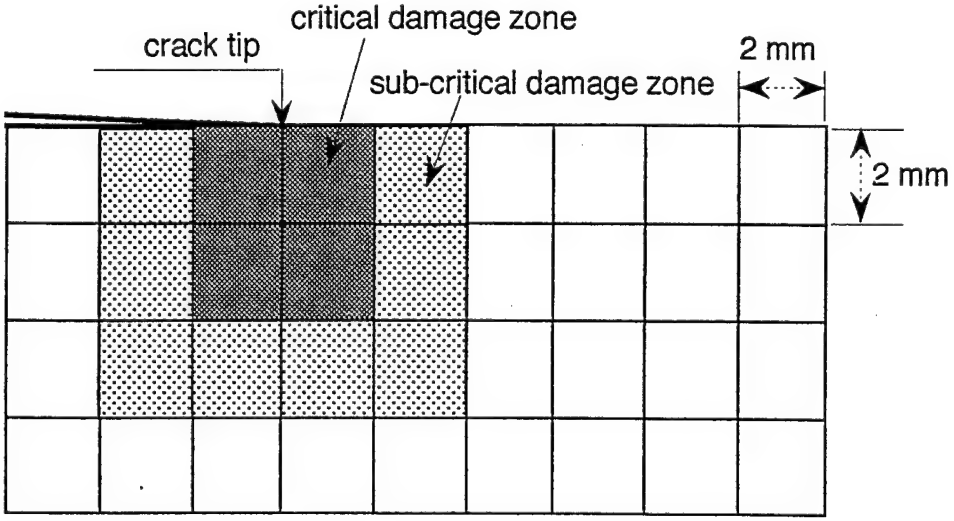
Figure xx - Ligament formation,020" thickness.



Highly Damaged Zone

Crack Tip Damage Model

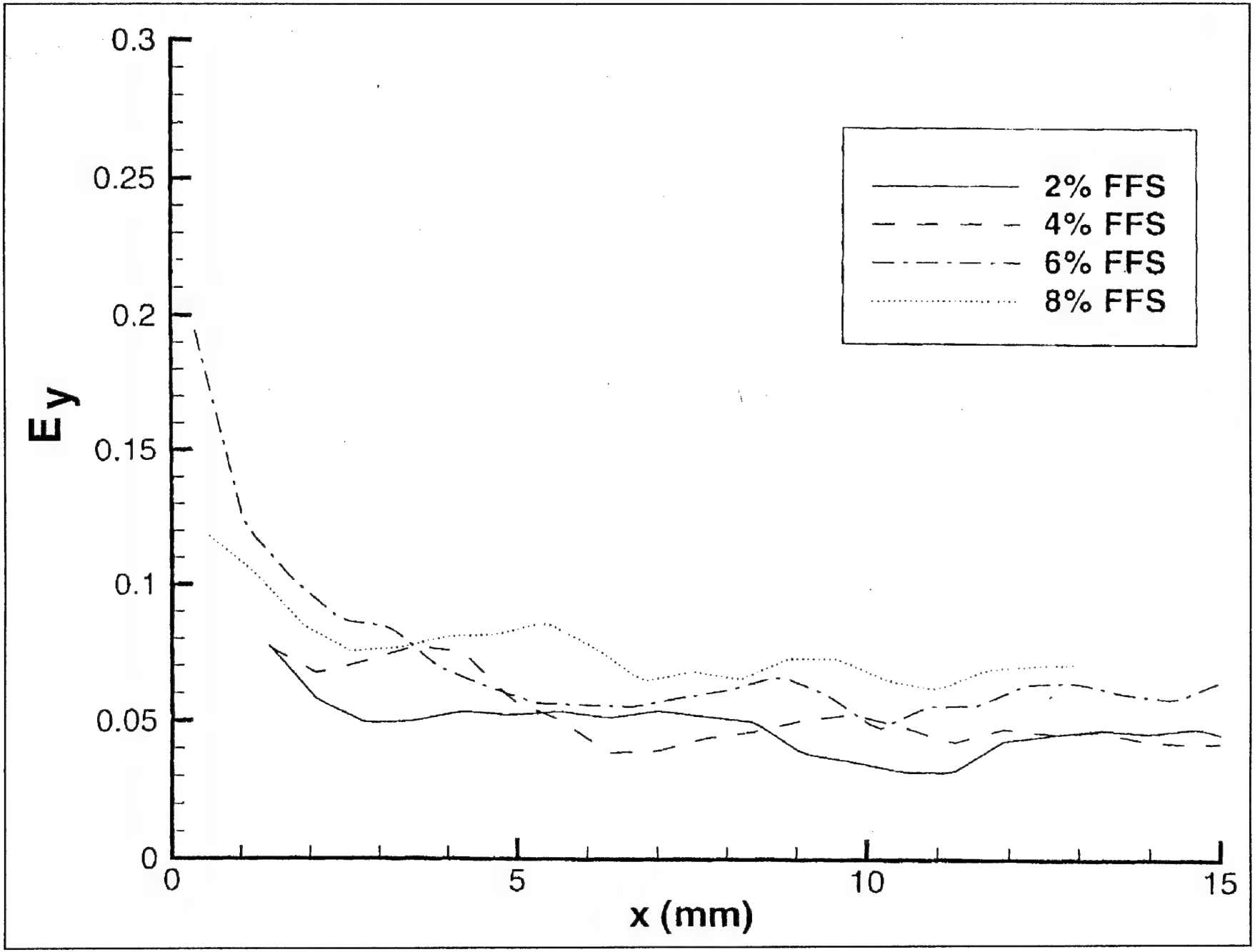




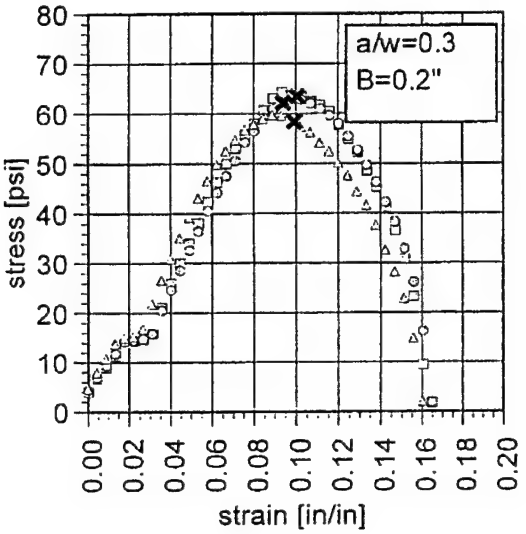
FEM mesh at crack tip

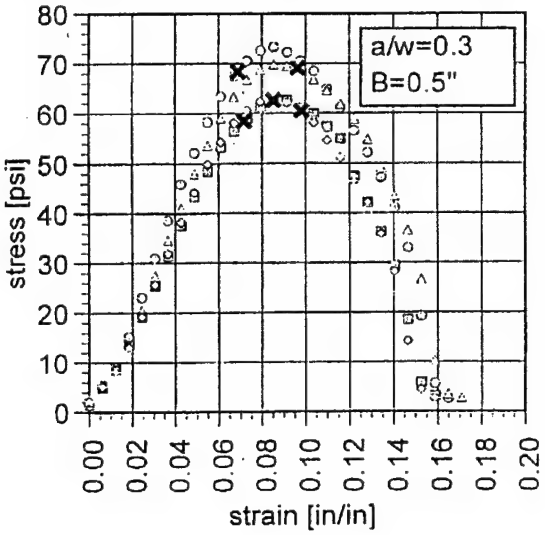
Table 1. Summary of crack-damage interaction analysis

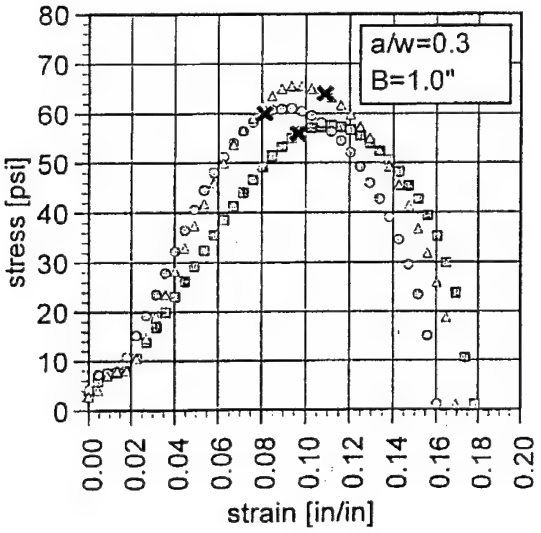
Case	Damage Element	Damage Element Modulus MPa (psi)	Poisson's Ratio	Inside Layer K_I MPa-cm$^{0.5}$	Middle Layer K MPa-cm$^{0.5}$	Outside Layer K_I MPa-cm$^{0.5}$
thin*	none	0.414 (60)	0.4999	1.871		
1	none		0.4999	1.931	1.903	1.802
2	325, 297	0.414 (60)	0.4999	0.422	2.246	1.871
3	325, 297 326, 298	0.414 (60)	0.4999	0.535	0.440	2.208
4	325, 297 326, 299 327, 299	0.414 (60)	0.4999	0.573	0.524	0.455
5	325, 297, 322, 294	0.414 (60)	0.4999	0.392	2.285	1.906
6	325, 297, 322, 294 326, 298, 323, 295 327, 299, 324, 296	0.414 (60)	0.4999	0.522	0.497	0.432
7	325, 297, 322, 294 326, 298, 323, 295 327, 299, 324, 296 353, 350, 347, 319 291, 263, 266, 269 354, 351, 349, 320 292, 264, 267, 270 355, 352. 349, 321 293, 265, 268, 271	0.414 (60) 0.828 (120)	0.4999 0.4999	0.546	0.514	0.442

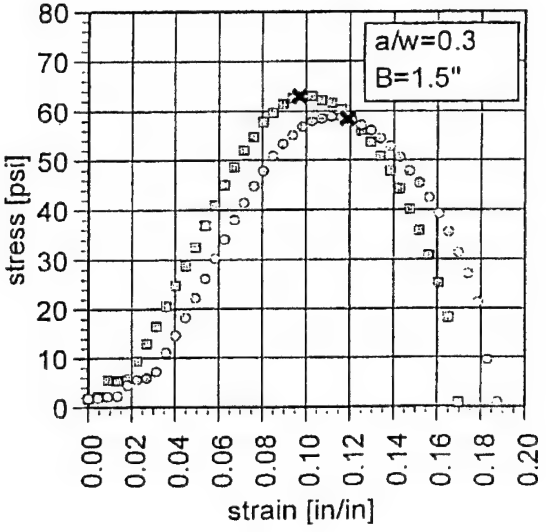

0.3
0.25
0.2
0.15
0.1
0.05
0
Ey
0
5
10
15
x (mm)
2% FFS
4% FFS
6% FFS
8% FFS

Fracture Specimens a/w = 0.3 (Ambient Pressure)



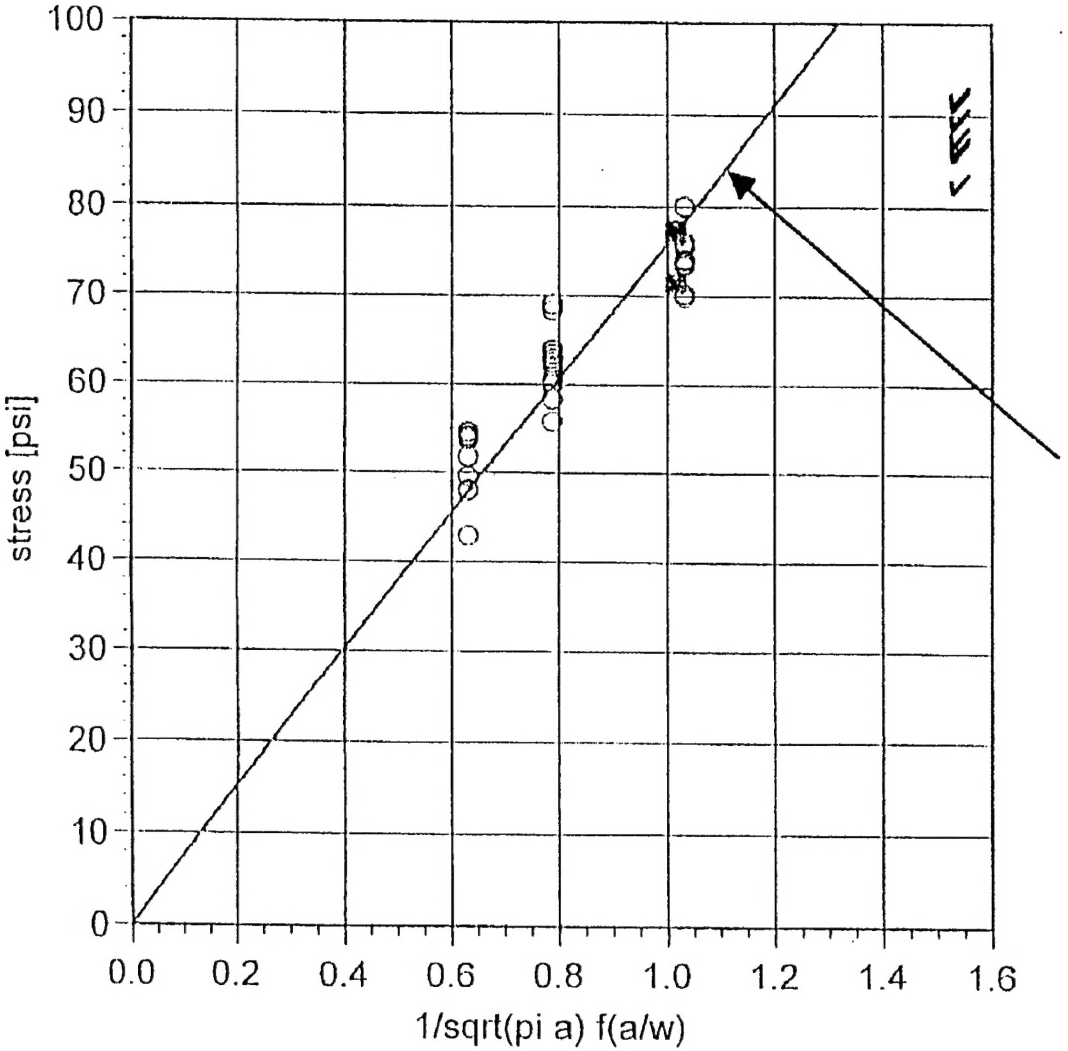






Regressive Calculation of K

Slope of Curve Gives Value for K



✔ a/w=0.1

✖ dogbones (a/w=0.3)

○ combined data

f(x) = 75.9 x R^2 = 0.88

Variations of Fracture Toughness at Crack Initiation with a/w, Thickness (Ambient Pressure)

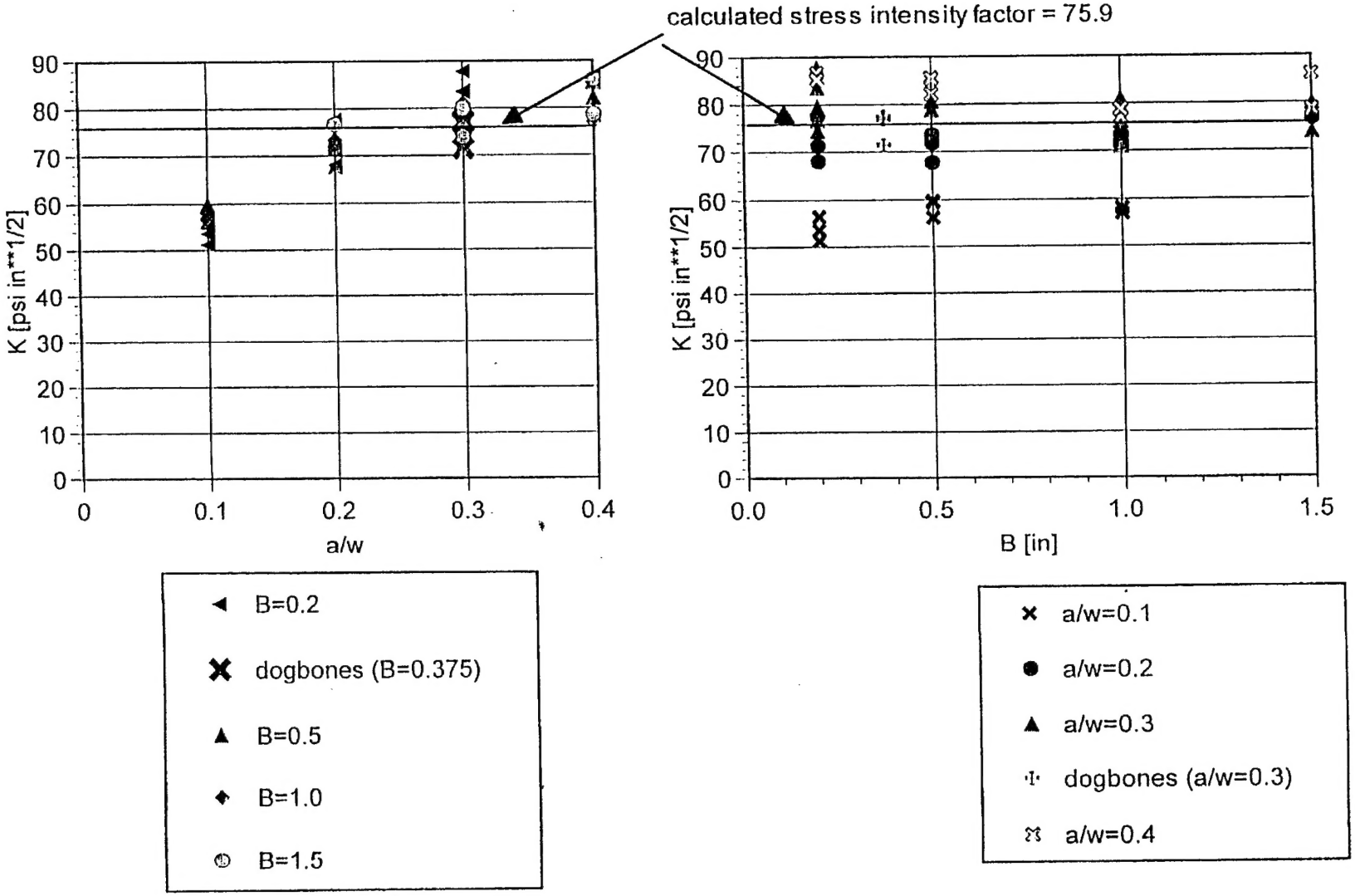
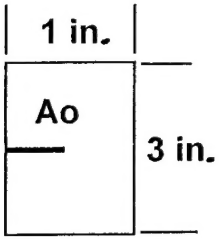


Table I Summary of K_{Ii} Value for Sheet Specimen* (Ambient Pressure, Strain Rate = 8 min^{-1})

Initial Crack Length Ao (in) \ Specimen Thickness (in)	0.2	0.5	1.0	1.5	K_{Ii} Average psi $\sqrt{in}$
0.1	53.81	58.51	57.75	52.46	55.63
0.2	72.38	71.10	72.15	66.10	70.43
0.3	80.41	77.92	76.08	74.20	77.15
0.4	85.76	84.34	78.14	83.51	82.94

* 

$$\left[\begin{matrix}(K_{Ii})\ 0.2, 0.3, 0.4 \\ \text{Average}\end{matrix}\right] = 76.84\ \text{Psi}\sqrt{\text{in.}}$$

Conclusions

1. Local Damage at the Crack Tip Minimized the Transverse Constraint.

2. The Initiation Mode I Fracture Toughness $K_{IC\,I}$ is Insensitive to the Specimen Thickness.

3. Linear Fracture Mechanics can be Used to Determine $K_{IC\,I}$ for Initial Crack Length Equal to or Greater than 0.2 in.

4. There is no ~~Plane~~ PLAIN Strain Fracture Toughness of this Particulate Composite Material.